In re Patent Application of:
AMMAR
Serial No. **09/863,030**
Filing Date: **May 22, 2001**
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At the outset, Applicant notes that the present invention is more than a millimeter wave device package that includes a number of dielectric layers and a MMIC chip. The present claimed invention is specifically directed to a thick film millimeter wave transceiver module having MMIC chips and circuits that form receive and transmit circuits for transmitting and receiving RF signals.

In the present claimed invention, a multi-layer, thick film substrate board is formed from a plurality of layers of low temperature, co-fired ceramic material, such as low temperature transfer tape. This substrate board is received on a base plate and MMIC chips are directly attached to the substrate board. The layers comprise at least one of a DC signal layer having signal tracks and connections that are embedded therein and a ground layer having ground connections. A device layer has capacitors and resistors embedded therein that connect to MMIC chips. A top layer has cut-outs for receiving the MMIC chips therein and is typically dimensioned at about 4 mils, which is about the thickness of a MMIC chip, as known to those skilled in the art. A solder preform layer is located between the device layer and the top layer and secures any MMIC chips, such as by direct die attachment using solder, such as a solder mask, or even epoxy in some cases. It is possible to use thermal vias under the chips to remove heat from the chips with the design of the present invention.

It should be noted that the Examiner has rejected all claims as either anticipated by U.S. Patent No. 5,451,818 to Chan et al. (hereinafter "Chan"), or obvious over Chan in

view of U.S. Patent No. 5,319,329 to Shiau et al. (hereinafter "Shiau"); U.S. Patent No. 4,506,122 to Wong et al. (hereinafter "Wong"); U.S. Patent No. 5,844,321 to Baudet; U.S. Patent No. 5,239,685 to Moe et al. (hereinafter "Moe"); U.S. Patent No. 5,254,941 to Osika; or U.S. Patent No. 6,426,686 to Douriet et al. (hereinafter "Douriet") or some combination of these patents.

As to the construction of the thick film millimeter wave transceiver module of the present invention, Applicant notes that the present invention is focused on millimeter wave transceiver design and construction. None of the references are primarily concerned with a transceiver, but more particularly, for more limited devices, such as the device holder in Chan. The transceiver design of the present invention uses a multi-layer, low temperature, co-fired ceramic material, such as low temperature transfer tape, where all the passives (capacitors and resistors), and the interconnects, are embedded in the layers and connected to MMIC chips. Neither Chan nor the other references disclose or suggest the embedded thick film capacitors and resistors.

In the present invention, a channelization plate is received over the multi-layer substrate board and has the channels formed to receive MMIC chips and provide <u>air</u> isolation between transmit and receive signals that pass through any transmit and receive circuits. This channelization plate can be formed as a channelized wire EDM (Electrical Discharge Machining) housing that isolates a receiver circuit from the transmitter circuit and allow even

greater than 100 decibel isolation for RF signal isolation. Applicant points out that this RF isolation created by the channelization plate is different from the electrical isolation provided by the vias in the ceramic material. Neither Chan nor the other cited references disclose or suggest the isolation through the air of the receiver from a transmitter, and thus, the transmit and receive signals as in the present claimed invention.

Applicant also notes that the inputs and outputs of the thick film millimeter wave transceiver module of the present invention are unique because with the present design, the coax connecters can be attached directly to the thick film substrate, while RF waveguide transitions can be printed directly on the substrate, as set forth in the disclosure and drawings.

In the present invention, the top layer has cut-outs for receiving MMIC chips therein. The use of a cut-out, and the thickness of the top layer of about 4 mils, as set forth in one dependent claim, can be advantageous to performance at very high frequencies. It is known that MMIC chips are about 4 mils, Thus, the thickness of the top layer can match the thinness of nearly all MMIC chips such that after chip attachment, the chip top surface lines up with a ceramic top surface and thus makes it easier to wire bond the chips and reduce the length of the wire bonds, which could be critical to performance of a millimeter wave transceiver. Thus, as in one claim, the solder preform layer is located between the

device layer and top layer for securing any MMIC chips and allow this structure and function.

As to Chan, Applicant notes that it is focused on hermetic millimeter wave ceramic packaging. The present claimed invention is opposite because it is a non-hermetic transceiver module design using metal and ceramic material. Hermetic modules would require the addition of expensive getter material to avoid hydrogen poisoning. The present invention could allow hydrogen to escape and eliminate the need for getter material. Chan does not noticeably discuss or suggest any method of MMIC chip attachment, as in the present claimed invention, and uses a direct die attachment to the low temperature, co-fired ceramic using a solder mask or possibly epoxy in some cases. This is reflected in the solder preform layer and set forth in Claim 16, where the MMIC chip is received on the substrate board and secured by a solder connection thereto, and connected to the embedded DC signal tracks and connections, and the capacitors and resistors embedded in the device layer. It is possible with this design to remove heat from the MMIC chips in a manner not disclosed or suggested by Chan through the use of thermal vias located under the MMIC chips.

It is also clear that Chan and the other references do not singularly or in combination disclose or suggest the use of embedded capacitors and resistors in the ceramic, and particularly in a layer of the ceramic material. The Examiner states that the capacitors and resistors are inherent in the MMIC chip, which is preferably the selection for the

electronic devices 30a and 30b, referring to column 3, lines 24-40 of Chan. Although most MMIC chips have on-board capacitors and resistors, it has been found that these are sometimes insufficient for bypass and biasing other MMIC chips. The additional external passive devices, such as the capacitors and resistors, are required and mounted near the MMIC chips. The present claimed invention has these passive devices as capacitors and resistors that are embedded in the interlayer of the ceramic material, thus, eliminating parts and reducing costs. Chan clearly does not suggest this in its language from lines 24-40 as cited by the Examiner and set forth below:

> "An electronic device, preferably an MMIC chip or other millimeter or microwave device or a multi-chip module, can be sealed in package 10, within seal ring 26. Although the figures illustrate a pair of devices 30a and 30b mounted inside package 10, it can be appreciated that package 10 can be appropriately configured to house only one or alternately an array of millimeter wave or other such devices, as well as other circuit components. Devices 30a and 30b are preferably mounted onto base 12, which preferably is formed to an appropriate height, or otherwise includes built-up surfaces 31, which are preferably made of the same material as base 12 and formed so as to support devices 30 in an optimum manner. Each device 30 is electrically coupled to one or more RF transmission lines 18, such as by wire or ribbon bonds 34."

As to the cited Wong reference, it is directed to the use of flip chip technology which is not used in the present invention, which instead uses straight chip and wire technology and solder. Thus, Wong actually teaches away from the present claimed invention.

As to Shiau, it is specifically directed to thin film technology instead of thick film substrate technology as in the present claimed invention.

Moe is directed to fabricating a MMIC hybrid device and transceiver that uses a base plate, feed through-holes to conduct ion paths, and a thick film deposition process to remove the organic material. It nowhere suggests the present claimed invention.

Baudet is directed only to soldering a semiconductor device on a support. It does not suggest a solder preform layer, or a layer located between the device layer and the top layer that forms part of the multi-layer thick film substrate board from the low temperature, co-fired ceramic material.

Osika is a wafer substrate test structure that uses isolation using vertical grooves or trenches. This is not the same as the isolation vias that provide electrical isolation by vias in the ceramic. In addition, of course, RF isolation can be provided by the air isolation provided by the channelization plate.

Douriet is directed to a microwave circuit package that uses silver epoxy with a MMIC. It nowhere suggests the structure and function of the present claimed invention.

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Applicant contends that none of the references either singularly or in combination disclose or suggest the present claimed invention.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned **"Version With Markings to Show Changes Made."**

Applicant contends that the present case is in condition for allowance. If the Examiner has any questions or suggestions for placing this case in condition for allowance, the undersigned attorney would appreciate a telephone call.

Respectfully submitted,

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CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: **DIRECTOR, U.S. PATENT AND TRADEMARK OFFICE, WASHINGTON, DC 20231**, on this 22nd day of January, 2003.

Julie Lalan

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

Claims 1, 10, 16 and 26 have been amended as follows:

1. (ONCE AMENDED) A thick film millimeter wave transceiver module comprising:

base plate;

a multi-layer<u>, thick film</u> substrate board [having a] <u>formed from a</u> plurality of layers of low temperature [transfer tape] <u>co-fired ceramic material</u> and received on said base plate <u>and MMIC chips directly attached to the substrate board,</u> said layers comprising at least one of

a DC signals layer having signal tracks and connections;

a ground layer having ground connections;

a device layer having capacitors and resistors embedded therein <u>that connect to MMIC chips</u>;

a top layer having cutouts for receiving MMIC chips therein;

a solder preform layer located between said device layer and said top layer for securing any MMIC chips; and

a channelization plate received over the multi-layer substrate board and having channels formed to receive MMIC chips and provide <u>air</u> isolation between transmit and receive signals.

10. (ONCE AMENDED) A multi-layer thick film substrate board used in transceiver modules comprising:

a plurality of low temperature transfer tape layers, said layers comprising one of at least:

a DC signals layer having embedded DC signal tracks and connections;

a ground layer having ground connections;

a device layer having capacitors and resistors embedded therein that connect to MMIC chips;

a top layer having cut-outs that receives MMIC chips therein; and

a solder preform layer located between said device layer and said top layer for securing any MMIC chips received within the cut-outs of the top layer [sheet].

16. (ONCE AMENDED) A thick film millimeter wave transceiver module comprising:

base plate;

a multi-layer, thick film substrate board received on said base plate and [having] formed from a plurality of layers of low temperature co-fired ceramic material [transfer tape], said layers comprising one of at least

a DC signals layer having embedded DC signal tracks and connections;

a ground layer having ground connections;

a device layer having capacitors and resistors embedded therein;

a top layer having cut-outs for receiving MMIC chips;

a solder preform layer located between the device layer and top layer;

at least one MMIC chip received on the [substrate board] solder preform layer and secured by a solder connection thereto and operatively connected to said layers, including said embedded DC signal tracks and connections and capacitors and resistors embedded in the device layer; and

a channelization plate received over the formed multi-layer substrate board and having channels formed to receive MMIC chips and provide air isolation between transmit and receive signals.

26. (ONCE AMENDED) A method of forming a thick film millimeter wave transceiver module comprising the steps of:

forming a base plate;

forming a thick film, multi-layer substrate board [having] from a plurality of layers of low temperature [transfer tape] co-fired ceramic material;

receiving the thick film, multi-layer substrate board on the base plate, wherein the substrate board comprises one of at least

a DC signals layer having signal tracks and connections;

a ground layer having ground connections;

a device layer having capacitors and resistors embedded therein;

a top layer having cutouts for receiving MMIC chips therein; and

securing the MMIC chip by solder <u>onto the thick film multi-layer substrate board and operatively connecting the capacitors and resistors embedded within the device layer to the MMIC chip</u>.